A SYMPOSIUM ON ATOMIC STRUCTURE AND VALENCE

AN INTRODUCTION

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The ever-pressing problem of the nature of matter has advanced to the center of chemical and physical interest now more than ever before by the new theories of Heisenberg and Schrödinger, respectively termed quantum mechanics and wave mechanics. The questions on every side are, "What *can* we believe and teach about the atom," and "What next?"

Not so long ago unprejudiced observers might have been wondering if the chemist with his static atom could ever come into agreement or understanding with the physicist's dynamic, infinitesimal solar system or whether indeed there was any effort to meet on a *common* ground by the different means of approach. Both atomic pictures were clearly based on the experiments proving a nuclear structure. Here at least was something in common. Both pictures were useful, the one to explain chemical combination and valence, the other to account primarily for the facts of radiation quantities. On the one hand we have the fruitful contributions of Kossel, Lewis, Langmuir and others; and on the other, the remarkable deductions of Bohr, first for the simple hydrogen atom. While the mechanisms involved in these atomic pictures to account for such chemical facts as stereoisomerism or for the physical facts of emission of radiant energy, seemed remote, some efforts were made to bring chemists and physicists to a common point of view.

Certainly it may be asserted, in spite of discrepancies and dis-

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agreements, that in the first quarter of the twentieth century, the actual existence of an atomic world became an established fact. Part of the difficulties in details may be ascribed to failure of chemists to test their well-founded conceptions with the facts of physical experimentation, and far too few physicists inquired critically into the facts of chemical combination. So, firmly entrenched each in his own domain, a certain long-range firing of static cubical atoms against infinitesimal solar atoms has ensued, with few casualties and few joint peace conferences.

The position of the Bohr conception has seemed so convincing that perhaps the majority of thinking chemists were coming to accept the dynamic atom, which is fully as capable of visualization as the conceptions placing electrons in definite positions in superposed shells. Valence and stereoisomerism were still difficult but it required only an exercise of faith or a stretch of the imagination to depict *orbits* instead of electrons in space. Thus Main-Smith arrived at spatial representations of electron orbital domains having the general shape, say of a pecan, as the locus of the precession paths of a valence electron moving on the surface of an imaginary solid ellipsoid of revolution with the nucleus at the focus. It is also true that Bohr, Stoner and others made use very largely of the facts of chemistry to extend the dynamic theory to more complex atoms marshalled in the periodic table.

But from the beginning it was extremely difficult to bring the fundamental hypothesis of Bohr into agreement with classical mechanics. Thus wave mechanics was founded in 1924 by Louis de Broglie,—new, though based on such century old conceptions as Fermat's optical principle, Maupertuis' mechanical principle and the familiar Huygens principle, and justifying Bohr's unorthodox mechanics in essence. Schrödinger derived a fundamental differential equation whose constant is an energy term which by its nature can assume only discrete values in the solution. In this way physical problems of atomic mechanics have been reduced to pure mathematics, but the success has been amazing. For the slightly earlier theory of Heisenberg, which had the object of removing from atomic mechanics those quantities which may not be directly measured by experiment such as the positions and velocities of electrons, now appears to be a necessary consequence of wave mechanics.

Shall now the chemist and the physicist dismiss from their ideas the picture of discrete electrons and quantum orbits and accept only the directly observable quantities characteristic of radiation which must be associated, complexly enough, with two atomic states? Is the atom which is radiating defined by the solution of a differential equation? Shall we say with Dr. Haas that "the second quarter of our century has convinced physicists that a *reality* can be ascribed to the world of atoms only in *another sense* than to that world which reveals itself to man directly through sensuous perception?"

Thus in the face of rapid and remarkable developments the time has seemed ripe to take stock of our conceptions of the nature of the matter. The chemist seeks light on the new wave-mechanics (which somehow has attributes remarkably reminiscent of the old static atom), and on the new experimental facts of radiation and of electrons reflected like waves from crystals. To a singular degree also many physicists are eager to acquaint themselves with knotty chemical problems of valence—for any theory ultimately must be found not wanting in its ability to account for these as well as for spectroscopy.

The Division of Physical and Inorganic Chemistry of the American Chemical Society undertook the task of sponsoring a stock-taking by inviting physicists, and physical, organic and colloidal chemists to contribute to a Symposium on Atomic Structure and Valence at the St. Louis Meeting of the American Chemical Society in April, 1928. So appreciatively was this program received, and so satisfactory seemed the joint stock-taking and mutually educative the coöperation that it has seemed the part of wise service to publish the papers there contributed as a monograph. Each paper represents a different approach to a complex central problem; they all present many debatable subjects, even in the least controversial topic of the nucleus.

Physicists bring the newest contributions of x-rays, of contemporary ultra-spectroscopy, of wave-mechanics. Chemists discuss the nucleus in its every aspect, make a genuine liason attempt to account for valence, outline with a challenge the old and new problems and theories of organic compounds, and present new physical methods of measuring chemical bonds, and strange phenomena in supermolecular states of matter. The Symposium is a cross-section of contemporary thought and achievement—heterogeneous, tentative, often discordant, at once clear and abstruse—and yet remarkably inspiring in the genuine effort to organize widely different fields of information into a true *general* science of matter and to press on to one of the great goals of intellectual endeavor. It is sincerely hoped that these papers may educate, refresh and stimulate in the general study and the seminar; and that they may be the documentary evidence of the welding in 1928 of Chemistry and Physics on a great common ground.